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Art. IV.—*On the Occurrence of a Felsitic Dyke and Associated Breccias at Sugar Loaf Hill (Mont Park), near Heidelberg.*

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(With Plate VI., and one Text Figure).

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Introduction.

Sugar Loaf Hill is an elongated hill running about north-north-west, and is 440 feet above sea level. It lies a little to the north of Heidelberg, and constitutes a prominent landmark, from which a fine panoramic view can be obtained.

As already pointed out by one of us (J.T.J.[1]) the hill is a monadnock on the Nillumbik Peneplain.

Previous literature.

References to this hill are few. Selwyn, in the map accompanying his report on the geological survey of the Yarra basin and Western Port,[2] has mapped it as a "siliceous dyke of red jasper and white quartz rock." On Quarter-Sheet 2 S.E. (Aplin, 1868), it is noted that on the hill there are outcrops of a "hard and flinty 'breccia,' composed of angular and here and there a few semi-rounded pieces of sandstone and altered shale," and the suggestion is made that this breccia has, in all probability, filled a pre-existing fissure in the bed rock.

Mr. T. S. Hart, M.A., in his "Volcanic Rocks of the Melbourne District,"[3] inclines to the opinion that Sugar Loaf Hill was once the bottom of a lava-filled valley, that the lava has been removed,

1 Proc. Roy. Soc. Victoria, vol. xxiii. (N.S.), pt. ii., 1911, p. 502.

2 "The Basin of the River Yarra and part of the Northern, North Eastern and Eastern Drainage of Western Port Bay." Votes and Proceedings, Leg. Council, Victoria, 1855-6, vol. ii., pt. i.

3 Vict. Nat., vol. xi., 1894, pp. 74-78.

but that the hardened drift of the stream bed remains, capping the hill.

Since Mr. Hart wrote, some very small excavations on the top of the hill have been made.

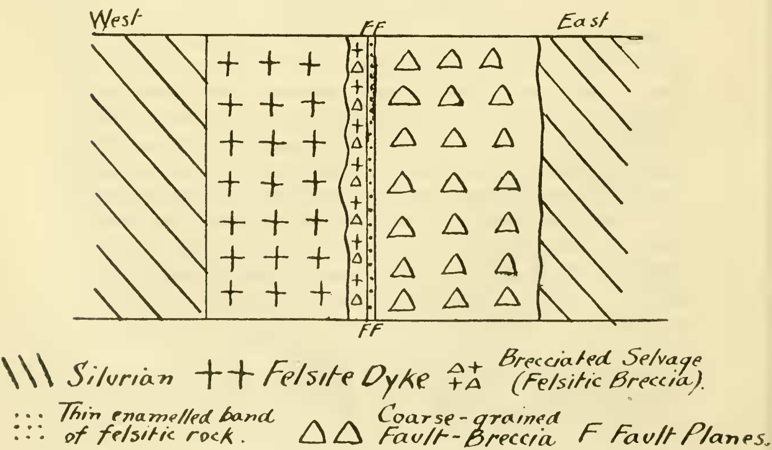
General Description of the Outcrops and Sections.

The country surrounding Sugar Loaf Hill consists of Silurian sediments (mainly shales with thin bands of sandstone), with a strike some degrees to the east of north. We believe the main part of the hill to be of similar lithological character, and the rocks to possess a similar strike, although the latter point is not directly ascertainable.

On the top of the hill a band of rock (which we regard as a felsitic dyke intrusive into the Silurian) runs approximately north-north-west for about 300 yards. A branch is thrown off from about the centre, and runs northerly for about 100 yards on the east of the main portion of the dyke. The outcrops are faint for about 50 yards north of the bifurcation. Between the two branches of the dyke there is exposed a moderately coarse-grained sandstone, with thin quartz veins. The width of the dyke varies from about 6 to 30 feet.

Associated with the dyke is a very coarse-grained breccia, which we consider to be a fault—or friction-breccia formed subsequently to the dyke.

At a shallow excavation about 18 inches deep, and about 3 feet long, towards the southern end of the main outcrop of the dyke, a small but interesting section is disclosed, which is shown by the following diagrammatic figure:—



The Silurian rocks are not seen in the actual section, but are inserted to show the relations.

The dyke at this section is about 12 feet wide; the brecciated selvage would average about 2½ inches, but reaches 5 inches; and the enamelled rock is about ¾ inch in width. The width of the fault-breccia has not been defined, but about 4 feet of it can be seen. The eastern face of the enamelled rock is smoothed, polished and marked by faint, approximately horizontal striations, evidently indicating considerable rock movement. The petrology of this rock and of the dyke and selvage are described later.

The fault-breccia is composed of angular fragments of apparently fine-grained sedimentary rocks (no doubt of Silurian age), of the dyke rock and of the selvage, the size of the fragments varying from about 10 inches to ¼ inch.

The selvage, on its western side, passes into the dyke by an irregular, indistinct line, the rocks having the appearance of being fused together. The junctions of the enamelled rock with the selvage and the fault-breccia respectively are sharp, practically vertical, and run approximately parallel to the course of the dyke; they are regarded by us as fault planes. The actual junctions of the dyke and the fault-breccia respectively with the Silurian cannot be seen.

At another small excavation (now filled in), and elsewhere on the hill, generally similar relations between the main rocks occur. Points of difference are that the selvage is nearly three feet wide in places, and is sometimes cavernous, and that well down on the south-eastern slope of the hill, a coarse-grained breccia occurs, but the dyke appears to be absent.

On the northern slope of the hill, and a few feet below its summit, there is a small outcrop of hard silicified coarse grits. These rocks evidently belong to the series of Kainozoic gravels and grits capping the hills at Preston, Northcote, Heidelberg, Studley Park, and other places. They do not appear to have been disturbed by any earth movement.

Petrology.

The following is a description of the three principal types of rock.

The dyke rock is compact, of a chalky-white appearance, obscurely laminated near its edge, and in places stained with iron. Traversing the rock are numerous small, irregular planes, which may be due partly to shrinkage on cooling, and partly to the severe pressure the rock has sustained during the various earth movements, which have occurred subsequent to its intrusion. Along certain planes, bands of the brecciated selvage occur, showing clearly that the brecciation of the dyke was not confined to its eastern edge.

Under a high power of the microscope, thin sections (Plate VI., fig. 4) are seen to consist of a felsitic ground mass with altered felspars giving a shadowy extinction, small blebs of quartz, numerous tufts of sericitic mica, and occasional pale green tourmalines. On the field evidence the rock would be classified as an acid dyke. Under the microscope, however, on account of the decomposition that has taken place, it might possibly be regarded either as a fine-grained dyke-stone or as a volcanic ash; but from a consideration of both the field and microscopic evidence, we are of opinion that it is a fine-grained decomposed felsite.

The selvage rock from which the slide (Plate VI., fig. 3) has been taken is a brick-red jaspery breccia. Some of the included fragments measure as much as 11 mm. in diameter. These seem to have been originally sandstones and secondary quartz vein-stone. Certain of the quartz fragments are distinctly rounded (due probably to crushing), and some show characteristic polysynthetic structure under crossed nicols. The brecciated rock-fragments are cemented by a ground mass of fine felsitic material, which has a purplish or reddish tint owing to the quantity of haematite included in it in segregation patches, and bordering the larger fragments of polysynthetic quartz. Sericite is abundant in minute flakes in the matrix of the rock, and traces of a large simply twinned orthoclase on the (?) Baveno type also occur. Many of the secondary quartz fragments show interesting stress shadows as well as micro-gneissic structure. Macroscopically this rock resembles a volcanic breccia, with included fragments of sedimentary Silurian torn from the rocks adjacent to the fissure. This term, however, generally implies a pyro-clastic rock formed by an explosion from a volcanic vent, which does not appear to be the case with the rock in question. It is better described simply as a felsitic breccia. It may have been formed either by the dyke on its intrusion tearing off fragments of the adjacent rocks, which became mixed with the dyke-stone at or near the margin of the dyke, or by earth movements causing the dyke to be brecciated subsequent to its consolidation. As the dyke-stone appears to form the matrix of the brecciated selvage, and the rocks have no distinct boundary line, but are irregularly fused together, we incline to the former explanation.

A certain amount of mineralisation of the rocks, particularly this selvage rock, has taken place, as shown by the thin veins and patches of pyrites and other minerals in hand specimens.

The enamelled rock is of an ochreous yellow to a brown colour. It resembles a fine-grained laminated ash breaking up into several distinct platy layers, disposed parallel to the wall of the fissure. Its eastern face is, as already noticed, polished, and faintly striated. The dynamical movement to which the rock has been subjected probably accounts for the laminated appearance.

This rock in thin sections (Plate VI., figs. 1 and 2) under a moderately high power, is seen to consist of fine felspathic material closely felted, with larger fragments of altered felspars and extremely angular fragments of quartz. These larger fragments are arranged rudely parallel to the walls of the fissure. The very fine felsitic constituents, by being impregnated with limonite, are not conspicuously anisotropic under crossed nicols, but the edge of this thin band of rock has lost its iron, being very clear in excessively thin sections, and giving striking polarisation effects. A still higher magnification reveals the presence of minute fragments of pale green augite, occasional red-brown rutiles, and numerous rounded crystals of zircon. Throughout the rock there are ragged fragmentary folia of biotite, whilst disseminated here and there may be seen limonitic granules, probably decomposition products resulting from the alteration of biotite, and other ferro-magnesian minerals.

The rock may be described as a fragmental felsitic rock resembling an ash, but its origin is a difficult problem. There are three posible solutions :—(1) A thin intrusion of a felsitic character much later than the main dyke itself; (2) a true acid volcanic ash; and (3) a fragmental rock due to the grinding of the walls of the fault fissure, the constituents of the rock consequently being derived largely from igneous rocks.

Concerning (1), it is difficult to understand the completely crushed quartz, and the entirely fragmental character of the matrix, for so much dynamical stress would surely result in chemical changes within the rock itself. With regard to (2) the microscope rather favours this suggestion, but it is difficult to account for such a thin band of volcanic ash in such a position, considering that it is clearly not interbedded with the Silurian sediments of the area, and that it is extremely unlikely that a narrow fissure would remain open, and become filled with pyroclastic material to such a depth as this fissure must have possessed, in view of the very considerable denudation to which the rocks must have since been subjected. The most favourable solution appears to be (3), but whilst we incline towards this idea, we think the origin of the rock must be left an open question for the present.

We are indebted to Mr. D. J. Mahony, M.Sc., for assistance in elucidating the petrology of the rocks examined.

Conclusions.

A dyke of felsite is considered to have intruded the Silurian sediments by a forked fissure across the line of their strike.

Associated with the dyke is a brecciated selvage, which we have termed a felsitic breccia. We consider it probable that this rock originated by the dyke on intrusion, tearing off and enclosing fragments of the adjoining rocks Another aspect has been mentioned above.

After the formation of the brecciated selvage, a strong earth movement took place, by which the present coarse-grained fault or friction breccia was formed.

Later, further dynamic changes occurred along the same line of fracture, as indicated by the features of the thin enamelled band of rock, but as the origin of the latter is not clearly determined. nothing very definite as to the displacement can be stated, except that it was, in part at least, almost horizontal.

Thus, including the original fissure, we have evidence of several distinct earth movements along the same line of fracture, and so strikingly confirming the general statement that lines of weakness often suffer from repeated displacements. The rocks have probably been altered by thermal waters as well as by dynamic agencies.

Rgarding the age of the dyke and breccias, if our reading of the phenomena be correct, they are clearly post-Silurian. The Kainozoic grits at the northern end appear to belong to the series of gravels and grits that cap the higher hills to the north-east of Melbourne, such as Northcote, Studley Park and Preston, which are regarded as Kalimnan. As these grits do not appear to have been affected by the earth movements, all such movements, together with the date of the intrusion of the dyke, must be regarded as pre-Kalimnan.

It is possible that the dyke is contemporaneous with the felsitic dykes, which can be seen intruding the Silurian along the Alexandra Avenue, Melbourne.

EXPLANATION OF PLATE

Plate VI.

Fig. 1.—Fragmental felsitic rock from the enamelled band in section near southern end of outcrop, Sugarloaf Hill. Slide No. 1. × 28.

Fig. 2.—The same, more highly magnified. Slide No. 1. × 184.

Fig. 3.—Felsitic-breccia, with quartz-vein fragments and altered sandstone, southern outcrops. Slide No. 2. × 28.

Fig. 4.—Felsite. From the dyke, southern outcrop. Slide No. 3. × 28.